Risk Assessment & Phase II Plans

INTEGRATE Annual Meeting

18 September 2019

Overview

- How well are we addressing the technology risks?
- What new risks have been identified? How will we address them?
- What's next?
  - Phase I, Year 2 Risk Reduction Plan
  - Phase II Overview
  - Phase II Application Spaces

Risk Matrix

Risks being addressed by each team in Phase I

#	Risk	1	2	3	4	5	6	7	8	9
1	Engine Integration	x	x	x		x		x	x	
2	BOP Synergies		x	x		x	x	x	x	
3	Stack Durability		x	x	x	x				
4	Stack Specific Power (W/kg)		x	x	x	x			x	
5	Stack Manufact. Cost ($/kg)				x	x				
6	Controls	x	x							x

Risk Reduction Plan (1 of 2)

Color-Coded
STATUS UPDATE

*Targeted risk progress during **Year 1** of Phase I*

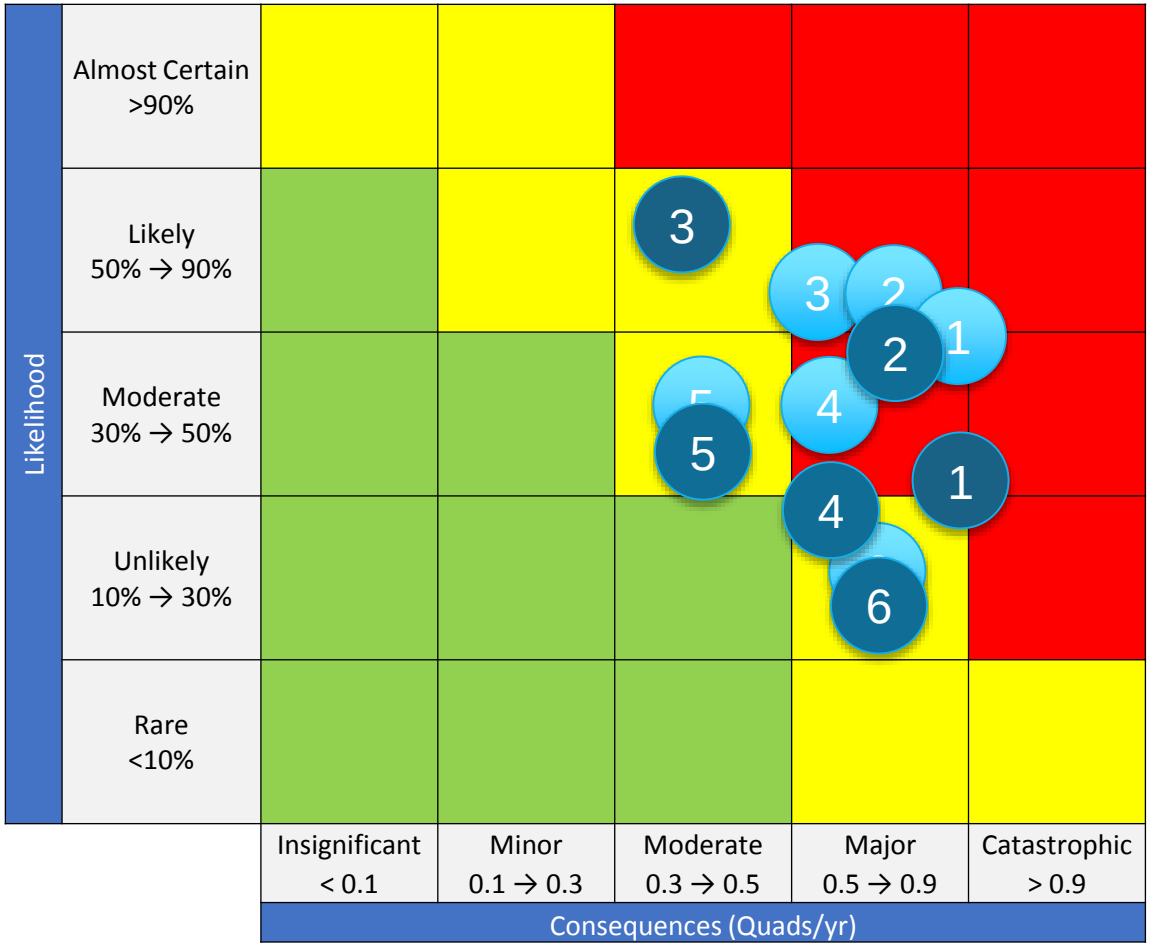
#	Risk	Year 1 Milestones
1	Engine Integration	• System designs complete • Low energy content fuel engine operation
2	BOP Synergies	• System designs complete • Power electronics design finalized
3	Stack Durability	
4	Stack Specific Power (W/kg)	• Sub-scale pressurized stack testing complete • Pressurized cell testing complete
5	Stack Manufact. Cost ($/kg)	• Full-scale pressurized stack designs complete
6	Controls	• Steady-state control strategies developed

Risks to Ultimate Goal – 2019 Update

P (kW)	>100
η	>70%
Eq. Cost ($/W)	<1
Maint ($/kWh)	<0.02

1 Quad/year INTEGRATE-Enabled Primary Energy Savings

Risk	#
Engine Integration	1
BOP Synergies	2
Stack Durability	3
Stack Specific Power (W/kg)	4
Stack Manu. Cost ($/kg)	5
Controls	6



Key Risks Identified during Phase I, Year 1:

- Need pressurized stack testing facilities
- Need high temperature, low cost heat exchangers
  - Ideally ceramic or alumina-forming-alloy (AFA) metal
- Cr-poisoning of SOFC cathodes a significant durability risk

Risk Reduction Plan (2 of 2)

*Targeted risk progress during **Year 2** of Phase I*

#	Risk	Year 2 Milestones
1	Engine Integration	• ICE operation on anode exhaust *(UW, CSM, SUNY)* • SOFC-GT system design finalized *(SG)* • O2 recovery demonstrated using O2 transport membrane *(WSU)*
2	BOP Synergies	• Elevated pressure reformer & hotbox testing completed *(SG)* • Heat exchanger prototype manufactured & tested *(ORNL)* • Power inverter development complete *(CSM)*
3	Stack Durability	• Full-scale stack testing for 100's of hours *(CSM, SG, Nex, FCE)* • Sub-scale stack testing for 100's of hours *(WSU)*
4	Stack Specific Power (W/kg)	• Full-scale stack testing for 100's of hours *(CSM, SG, Nex, FCE)* • Sub-scale stack testing for 100's of hours *(WSU)*
5	Stack Manufact. Cost ($/kg)	
6	Controls	• Full transient control and operational strategies developed *(NETL)*

Phase II Plans

- Funding pitch to ARPA-E Leadership by end of 2019
  - Targeting ~$30^{+} M program
- Full-scale (TRL 5) demonstrations of 3-4 systems
- ARPA-E interested in hybrid systems for the following application spaces:
  - Stationary Distributed Generation *(original)*
  - Transportation: Marine
  - Transportation: Aviation
- Teams that originally proposed a Phase II will need to submit an updated Phase II proposal
  - Adjustments to teaming and final product definition are allowed